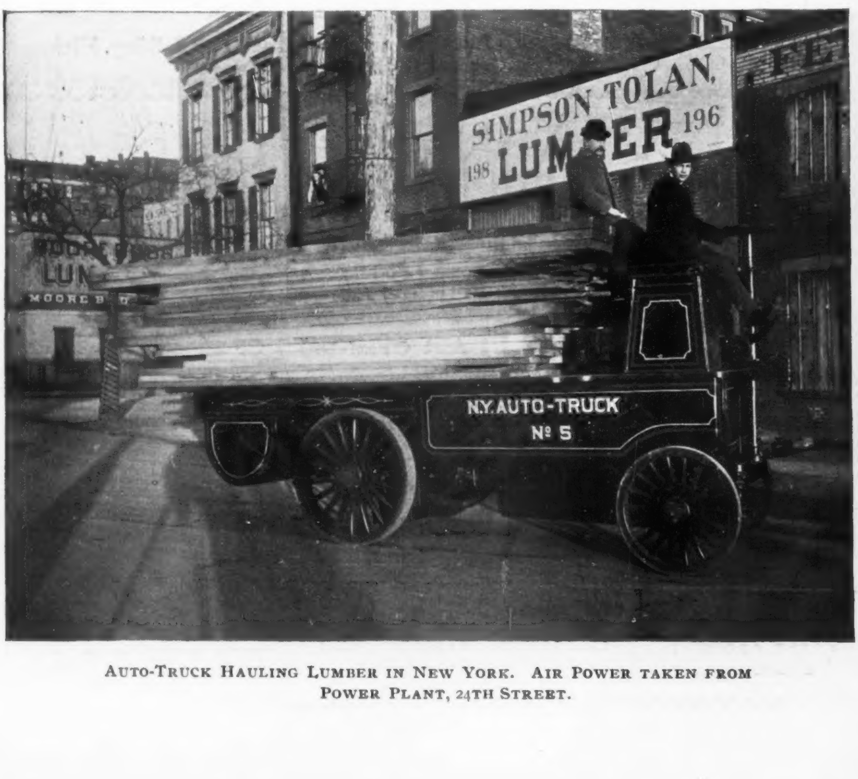
Compressed Air

DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. V. NEW YORK, MARCH, 1900. No. 1



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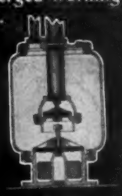

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Compressed Air.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
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Union City, Tenn., Feb. 15, 1900.

Editor of Compressed Air:

Dear Sir—I desire to submit the following questions to be answered through the columns of "Compressed Air":

First. Is there any difficulty in transmitting compressed air and reheating it for power purposes?

Second. Does the back pressure from expansion in the reheater interfere with the flow of the air through the pipe leading to the reheater?

Third. Can compressed air be forced through a reheater at as low a pressure as from 30 to 45 pounds per square inch?

Trusting that these questions will be answered at an early date, I am very truly yours, A. J. HARPOLE.

Question I. Compressed air may easily be transmitted and reheated at the end of the line or at any point along the line for power purposes. This has been done for years past on large scales in Paris. (See "Compressed Air," August, September, October, 1899.) Another case on a large scale is the transmission plant at the Chapin Mines, Quinnesec Falls, Mich. (See "Compressed Air," page 6, Vol. 1; page 107, Vol. 1.)

Another case is that of Jerome Park, N. Y., where a central plant is located and air transmitted in different directions and used for driving rock drills, pumps, etc. (See "Compressed Air," page 97, Vol. 1.)

The difficulty in transmitting compressed air long distances arises only when large volumes of air are transmitted. In these cases the size of pipe and the nature of the country over which the pipe is to be laid must receive attention, and careful figuring only can determine whether it is best under certain conditions to transmit pneumatically or electrically. Electric transmission long distances and in large power units may be more easily and more economically installed where the nature of the country is rough and mountainous, and where the distance is great, say from five to ten miles or more. In such cases it is usual to transmit electrically at high pressure, thus calling for a conduit of moderate dimensions and comparing favorably with the large compressed air pipes. The high-pressure electric current is reduced to low-pressure at the work. Compressed air, too, may be transmitted at high pressures and used, but this calls for extra heavy pipes and careful protection against leakages through expansion and contraction. Each case should be considered by itself, and a comparison of figures made, based on the conditions as they exist.

Question II. There is no back pressure due to reheating at the end of a pipe line. The reheater expands the air and causes a reduction in the velocity of flow from the compressor to the reheater. Each pipe line is proportioned in diameter of conduit to the velocity of flow, which is dependent on the volume and the pressure, thus a reheater used on the end of a line may admit of a smaller diameter of conduit because it thins out the

compressed air, reducing its density, and as the pressure remains the same it practically enables the user to do more work with a definite given volume of compressed air at normal temperature.

Question III. Compressed air is not necessarily forced through a reheater; it passes through naturally, and at a velocity dependent on its pressure and upon the construction of the heater. These heaters as commonly constructed might do good work with compressed air at a pressure as low as ten pounds per square inch.

Compressed Air Machinery

The Speed of Air Compressors.

By Frank Richards.

The following letter has been handed to me:

"I have never seen in the American Machinist any discussion as to the proper speed of an air compressor. What speeds are and what are not practicable? It is obvious to those who have looked into the matter that the speeds of air compressors are commonly low, but whether this is imperative, or whether it is only that present practice has not yet reached the permissible speeds, is the question, and if much higher speeds may yet be employed, what are the present hindrances and what the most promising means for overcoming them? These things seem to me to offer a very good field for useful statement and discussion, and I should be much interested, and I believe many others would be, if the subject were taken up in your columns. "A Subscriber."

The ultimate speed of an air compressor, like that of a steam engine, is the result of a compromise. It is of course desirable that any machine shall accomplish as much as possible, and the inevitable impulse is to speed it up. There is, however, always reached a limit beyond which the speeding up ceases to be profitable. None can be more interested in developing the highest efficiency in any class of machinery than the builders of such machinery, for those who can show the highest efficiency have the best of the argument with the customer. In their search for the higher efficiencies the builders also, if in healthy communication with the users of their machinery, have the best opportunities for learning the conditions, including in this case that of piston speed, which limit and determine the capacity. When the builders publish tables of data concerning their air compressors of different sizes and styles, including piston speeds and volumes of air compressed, we may assume that they speak from the most reliable knowledge, and that they are at the same time disposed to make as good a showing as possible. I have before me the catalogue of one of the largest and most successful builders of air compressors, in which are given the piston speeds of a large number of their machines. These speeds range from 150 feet to 620 feet per minute, the former being for little machines of only 6-inch stroke, and the latter for the largest Corliss engine compressors of 5-foot stroke.

Now, it is rather a matter of taste as to what we shall call fast and what we shall call slow. Our correspondent above would call these speeds slow, while I would not. Steam-driven air compressors usually have no governors or speed regulators, so that they may be speeded up by simply turning the throttle wheel, but not with all-around satisfaction. A large increase of speed will usually give but a small increase of delivery, and the valves and working parts of the machines suffer rapid wear or frequent breakage. Air compressors are often installed for a single job, as for operating rock-drills where a long tunnel is to be driven or a deep shaft sunk, and here little care is given to the compressor if it will but stand by the job to completion, and damage to it is little thought of if large volumes of air can be delivered, and in such service the speed limits of air compressors have been thoroughly, if not closely ascertained.

The objections to high speed for an air compressor begin, right at the beginning, with the operation of getting the air into the cylinder. During the intake stroke, as the piston recedes the air is, of course driven into the cylinder by the pressure of the external atmosphere. To cause the

air to flow in there must always be a difference of pressure between the inside and the outside of the cylinder, and the pressure outside can be nothing more than the normal atmospheric pressure, so that the pressure within the cylinder on the intake stroke must always be something less than this. To increase the velocity at which the air must flow in, and especially to start the flowing of the column of air more frequently, as must be done when the speed is increased, demands a greater difference between the internal and the external pressures, or a reduced pressure within the cylinder, and this must mean that a less weight of air will constitute a cylinderful, and less air will be compressed and delivered per stroke.

An additional loss is entailed by an increase of speed in the case of the two-stage compressor, as it must necessarily affect, and always disadvantageously, the efficiency of the intercooler. The intercooler is the only justification of the two-stage compressor, and a two-stage air compressor without an efficient intercooler is a mechanical absurdity. Power is saved by cooling the air after it is partially compressed and so reducing the volume to be operated upon in the second cylinder. The best intercooler at its best is not too efficient, and as when the speed of the compressor is increased the heated air must pass through it more frequently and more rapidly, it cannot be as completely cooled.

An increase in the speed of the air compressor means also increased difficulty in properly lubricating the cylinder. With an initial temperature of 60 degrees Fahrenheit, the final temperature of the air in the cylinder of a single-stage air compressor when delivering air at, say, six atmospheres is above 400 degrees, while in the first cylinder of a two-stage compressor it is nearly 300 degrees, so that the difficulty of maintaining proper lubrication may easily be appreciated. The water jacket may not count for much in its effect upon the air within the cylinder during the compression stroke, but it is of great service in keeping the inner surface of the cylinder at least cool enough to prevent the actual burning of the oil. This service is quite seriously impaired if the piston speeds are much increased. The failure of the lubricant, and the burning and cutting of the cylinder and valve surfaces are familiar and costly experiences accompanying the reckless speeding up of compressors.

There is positive danger in running a compressor at such a speed that the air cooling devices employed do not have sufficient time to do their work completely. Serious explosions have been caused by the ignition of mixtures of oil vapor and air in the cylinders or other parts. One such accident occurred within my knowledge quite recently, in which the intercooler between the cylinders of a compound compressor was blown to pieces, and an important service was interrupted for a long time in consequence. In some cases men have been killed by similar accidents.

And then there is the trouble with the pounding of the valves. The maintenance of the valves of the compressor is usually the largest item of repairs. They are usually poppet valves, and the elasticity of the air causes them to move in both directions at a lively gait and to strike hard, and of course this is much worse at high speeds. There may yet be devised valves with sliding movements that will avoid some of the most objectionable features of the poppet valves, and, so far as they are concerned, make somewhat higher speeds permissible, but they will be more than likely to bring other troubles in their train as great as those which they attempt to cure, and especially in the difficulty of proper lubrication.

Thus there are several particulars to be suggested which tend to limit the profitable speed of the air compressor. They are none of them of a character to be handled with figures and formulas, but experience speaks with sufficient clearness and sharpness in the matter. It is not probable that much higher speeds will be established for air compressors than those now prevailing. The limit will, of course, be where it does not pay, all things considered to run any faster. —*American Machinist.*

The Use of Compressed Air in the Freight Yard of the Lake Shore and Michigan Southern Ry. at West Seneca, N. Y.

A modern freight yard cannot be considered complete unless it is provided with a compressed air plant for testing the brakes on cars when made up into trains before departure, and also for use

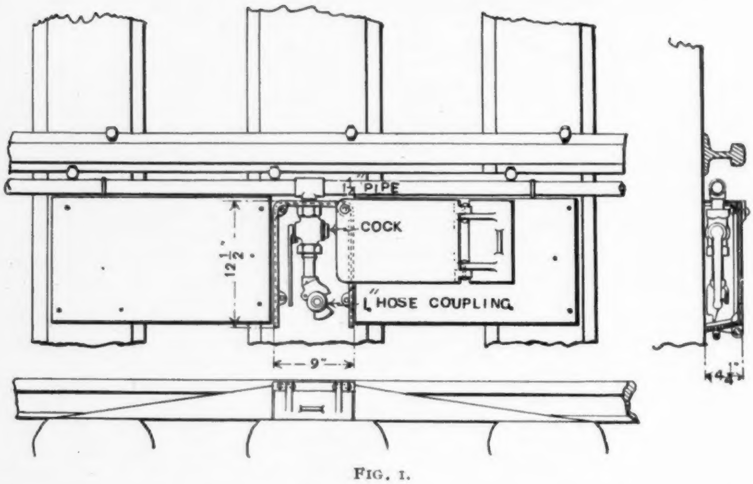


FIG. 1.

on the repair track, both for testing brakes and for facilitating the work of repairs. With such a plant the inspectors and repair men have compressed air "on tap" at all times and are, therefore, not compelled to wait for the locomotive to be attached to the train before it can be tested, thus eliminating all delays and having the train ready to leave when the engine is attached.

About three years ago the Lake Shore & Michigan Southern R. R. Co. established at West Seneca, near its eastern terminus, a new freight yard, in which a compressed air plant was installed which meets all requirements in this line.

Compressed air is furnished by a duplex compound air compressor, having a capacity of 342 cubic feet of free air per minute. It is located in the machine shop near the round house and delivers the air into a storage reservoir of about 100 cubic feet capacity located outside of the building. This storage tank is chiefly for the purpose of equalizing pressure and for collecting moisture, for the larger part of the storage capacity of the plant is contained in the 25,000 feet of distributing pipes which are laid through the repair and inspection yards and have a volume, approximately 3,000 cubic feet. A safety valve is provided on the storage tank, which limits the pressure to 105 pounds per square inch, although a regulator on the compressor controls the pressure in such a way that there is seldom, if ever, any use for the safety valve.

The main feed pipe is 2 inches in diameter and is laid on top of the ground, where possible, and boxed in, to a point near the yard office, from which branch pipes of 1½ inches diameter extend to the repair and inspection yards.

The repair yard consists of six tracks, in two groups of three each, the entire space being planked over level with the top of the rail. Four lines of 1¼ inch pipe are laid through this yard, located midway between the tracks and fastened to the planking by ⅜ inch staples, each group being provided with a cut-out cock, so that it can be shut off for repairs without affecting any of the other lines. Connections for attaching hose are provided at every 50 feet, and are made of 1-inch Westinghouse hose couplings threaded and screwed into 1-inch cut-out cocks, and connected to tees in the pipe lines by nipples. These connections are protected from the weather when not in use, by cast iron boxes, which are shown in Fig. 1, and will be described later.

In the repair yard compressed air is used for testing the brakes on cars, and also for raising cars, which is done by means of pneumatic jacks, consisting of a case iron cylinder (Fig. 2) provided with a piston, the rod of which extends

through the top head and is provided at its end with a recessed casting which bears against the sills of the car when in use. Air is admitted under the piston by a ½-inch pipe provided with a cut-out cock; the inlet port in the lower head has in it a small check valve which prevents the air from escaping through the inlet pipe should a leak suddenly occur; to lower the piston the air is released by a separate pipe and cock. Two jacks are used to a car and they are connected to the air supply by hose, joined together by a Y-shaped nipple, so that each jack gets the same pressure and the car is raised equally on both sides. Two sizes of jacks are in use, 10 inches in diameter for light cars, and 18 inches for loaded ones. The larger jacks are mounted on wheels to provide an easy means of moving them from place to place; the smaller ones are light enough to be carried around, although trucks are provided which are used when they have to be taken any distance. Fig. 4 shows a pair of the heavy jacks in use under a car.

Air is also used in the repair yard to drive a pneumatic drill or boring machine, and also to furnish blast for the blacksmith forge.

In the inspection yard there is an air line of 1¼ inch pipe for every two tracks. It is laid on top of the ties, close to the rail and fastened by ⅜-inch staples. Connections similar to those on the repair track are provided every 100 feet and are enclosed on three sides by a cast iron casing, resting on the tie, the top and open end being closed when not in use by a hinged cover and end, which is turned out of the way when the test hose is connected. Fig. 1 shows the connection and box and their arrangement on the track. Wedge shaped pieces of timber are fastened on each side of the box on top of the ties, to prevent trainmen who are walking along the track from stumbling over the obstruction. On account of the length of the lines in the inspection yard, expansion joints had to be provided, which are in the form of U-shaped connections between the ends of sections of the pipe 300 feet long, and are made up of a union, nipples, elbows, hose nipples and short pieces of hose, as shown in Fig. 5. These joints are enclosed in boxes, protected by wedges, like the regular connection boxes. Each separate line is provided with a cut-out

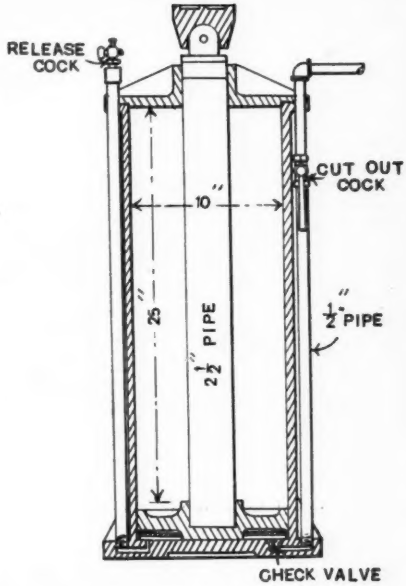


FIG. 2.

cock. The pressure of the air is reduced by means of a reducing valve to 70 lbs. before it passes into these pipes and the testing is done by means of an engineer's valve mounted on a wheel barrow and connected to the pipe line and the train by hose. After a train has been tested the train pipes are left charged, so that when the locomotive is attached no time is lost in pumping up the train.

Another plant at West Seneca, which depends largely upon compressed air, but which is separate and independent from that provided for the repair and inspection work, is that for supplying water for the various purposes around the yard, and also for elevating sand for use in locomotive sand boxes.

The water is taken from seven driven wells and also from a creek near by. The wells are from 100 to 105 feet deep, and the one in the creek is about 20 feet deep. Compressed air, at 60 lbs. pressure, is supplied by a straight line air compressor, having a capacity of 384 cubic feet of free air per minute, two compressors being provided to always have one ready in case of emergency. The principles of the Pohle air lift are made use of to bring the water to the level of

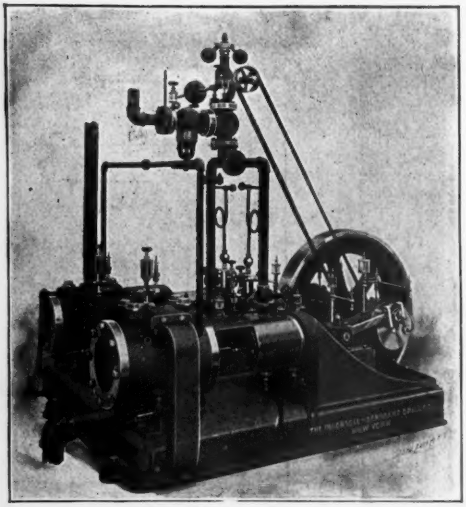


FIG. 3. CLASS H DUPLEX AIR COMPRESSOR. L. S. & M. S. RY.

the yard. The wells are of 6-inch pipe in which a piece of 2½-inch pipe extends almost to the bottom and a ¾-inch air pipe runs down on the outside and enters the 2½-inch pipe near its bottom. The escaping air draws the water up with it and delivers it through the 2½-inch pipe into a main, which carries it to a large surface well of 100,000 gallons capacity, which is floored and housed over and provides a place for the two air compressors and also two water pumps, which deliver the water from this well to the storage tank of 100,000 gallons capacity, 35 feet above the ground. From this point it is distributed to standpipes and hydrants at different points of the yard. The water pumps have a capacity of 500,000 gallons per day and are also in duplicate.

Sand for use on locomotives is thoroughly dried by steam and delivered by the drier near the floor level of the sand house, and is then blown from there to a reservoir on the upper level, from which it flows by gravity to the sand box of the locomotives through pipes with flexible joints. The apparatus for elevating the same consists of a 2-inch vertical pipe into the lower end of which a ¾-inch pipe extends, drawn down to a ⅜-inch nozzle, and when air is allowed to escape through this nozzle it draws the sand up with it and deposits it in the reservoir on top.

In the use of this apparatus it was found necessary to get rid of the moisture in the air by passing it through a chamber where the moisture could precipitate and be drawn off by a cock at the bottom.

The air compressors used in connection with these plants deserve more than a passing mention, as by their use a large saving is effected over the cost of operating other machines for doing the same work.

The compressor used in connection with the testing tracks and repair yard is a class H, Ingersoll Sergeant duplex steam driven air compressor with compound air cylinders (Fig. 3), having 10-inch steam and 16 and 10-inch air cylinders with a stroke of 10 inches, giving with 150 revolutions a capacity of 342 cubic feet of free air per minute. The steam cylinders are provided with plain slide valves driven by eccentrics.

The compressor used in connection with the water supply is a standard type made by the same company.

It still seems to be a mooted question among some railroad mechanical men as to what is the most economical machine for compressing air for shop use. Naturally the first machine used for this purpose at railroad shops was a locomotive air brake pump, of which there are always some spare ones on hand, and these can be used without their cost appearing on the books as a new investment. As the uses to which compressed air is put increased more than one pump was found to be needed to supply the demand and it was soon found that while there was no material outlay chargeable to shop equipment, there was quite a marked difference in the consumption of coal in the boilers, and it is now almost universally conceded that while the air brake pump is the best machine that can be procured when used in its legitimate sphere, i. e., on the locomotive for supplying air to operate the brakes, it is a very wasteful one when used to furnish a large supply for a shop plant, where floor space and water for cooling purposes are readily obtained, and the installation of an air compressor will soon show a marked decrease in coal consumption and repairs. Even when the demand for air is not sufficiently large to warrant the purchase of an independent

compressor, one driven by belt by the shop engine will show almost as much economy as a steam driven one.

On the locomotive the air brake pump runs comparatively slow, not pumping a very large amount of air, as after the train is charged it is only necessary to supply what is lost by leakage, excepting after brakes are released, when a few strokes of the pump will usually bring the pressure up to the maximum, and the repairs therefore are comparatively light. When used, however, to supply the large and constant amount of air needed in a shop plant, the wear and tear is considerable and the pump has to be repaired and many parts renewed at very short intervals.

condensing engine, showed 13.7 cubic feet of air per pound of steam. Assuming that the compressor which has been described as supplying air for the repair and testing yard at West Seneca delivered on an average 250 cubic feet of air per minute, which is less than 60 per cent. of its capacity, and assuming further that on account of having only a simple engine instead of compound, the free air compressed was only 10 cubic feet per pound of steam, which is probably too low, we would obtain a consumption of

$$\frac{250 \times 60}{11} = 1{,}364 \text{ lbs. of water per hour,}$$

which would require, assuming 8 lbs. of

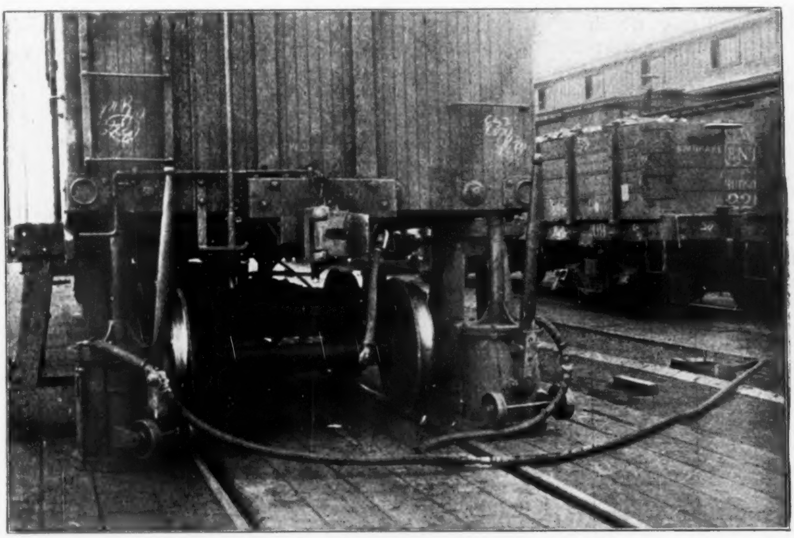


FIG. 4. AIR JACKS IN POSITION UNDER CARS.

Some years ago the Westinghouse Air Brake Co. conducted a series of tests to ascertain certain data in regard to the air brake pump as compared with air compressors, from the results of which tests some figures have been selected, which are given below.

The 9½-inch air brake pump compresses about 45 cubic feet of free air per minute to 90 lbs. pressure, or 2.5 cubic feet per pound of steam. A two-stage compressor, operated by compound non-

water evaporated by the boiler per pound of coal, 170 lbs. of coal per hour.

To compress the same amount of air by means of 9½-inch air brake pumps would require four or five of these, compressing 2.5 cubic feet per pound of water, which at the same figures as given would require

$$\frac{250 \times 60}{2.5 \times 8} = 750 \text{ lbs. of coal per hour, or 4.4}$$

times as much as required by the compressor.

Assuming a service of 300 days of 10 hours each per year, with coal at $1.00 per ton, the cost of fuel would be 170 × 3,000 × $1.00 = $255 for the compressor, and 4.4 times as much, or $1,122, for the pumps. The price of coal is taken at a minimum figure and the difference in cost will be much more at the price that is usually paid.

The consumption of water would be about as follows: The boiler would have to evaporate for the compressor 1,364 lbs. of water per hour, or about 481,400 gallons per year, for the air brake pumps 6,000 lbs. per hour, or 2,118,000 gallons per year. The compressor would further require for cooling purposes about five gallons per minute, or 900,000 gallons per year, making a total consumption of 1,381,400 gallons, which at 3 cents per 1,000 gallons is a conservative figure, and would amount to $41.44, while the cost of water for the air pumps would be $50.82.

The market price of a compressor of about the size and kind mentioned is approximately $1,700, while that of one 9½ inch air pump is $125.00. Allowing 5 per cent. annually for interest on equipment and 10 per cent. for wear and tear, the latter being high for the compressor and low for the pump, and tabulating all the above figures we get the following:

	First cost.	Expense for 1 year.				
		Fuel.	Water.	Interest.	Depreciation.	Total.
1 compressor.....	1700	255	41	85	170	551
6 air brake pumps (9½"in.)........	750	1122	63	37	75	1297

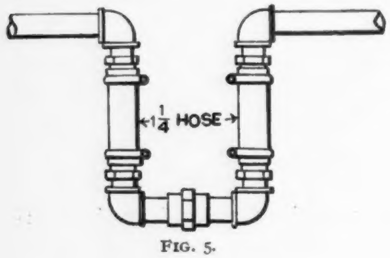


FIG. 5.

From which it will be seen that the cost of running the air brake pumps would be 2.4 times as much as that of the compressor and the latter would save its cost, on running expenses alone, in a little over two years, or would almost save the difference in first cost during the first 15 months.

It might be urged that air brake pumps could be used which had previously been in service on locomotives and that there would then be no expense for first cost. Nevertheless the pumps would have been paid for at some previous time, and they represent the investment of a certain amount of money, so that the interest and depreciation should still be considered in their running expenses. When old pumps are used for shop purposes, it is usually the 8-inch pumps that are taken which have been replaced on locomotives by those of larger capacity; these may be valued at $100 each, although the cost of a new one at the present time is higher.

Reverting to the tests referred to as made by the Westinghouse Air Brake Co., it was found that an 8-inch pump compressed 1.85 cubic feet of free air per pound of water. It would therefore require, using the same figures as before,

$$\frac{250 \times 60}{1.85 \times 8} = 1{,}014$$ lbs. of coal per hour to pump the same amount of air by means of 8-inch pumps, or six times as much as required by the compressor, and the cost per year would be $1,530. The water consumption of the pumps would be 2,455,200 gallons per year, costing $73.65. Tabulating these figures we have the following:

	First cost.	Expense for 1 year.				
		Fuel.	Water.	Interest.	Depreciation.	Total.
1 compressor ...	1700	255	41	85	170	551
10-8 inch airbrake pumps.........	1000	1530	73	50	100	1753

From which it will be seen that the 8-inch air brake pumps will cost more than three times as much as the air com-

pressor to operate, and that the compressor will pay for itself in less than a year and a half.

When it is further considered that the compressor requires, if anything, less attention than a number of pumps, that the consumption of oil would certainly be less for the compressor, and that the cost of repairs would be considerably in its favor it would seem that a railroad which continues the use of air brake pumps for shop purposes is maintaining a losing investment.—*Railroad Car Journal.*

Miscellaneous Applications of Compressed Air

The Use of Pneumatic Rammers.

Power rammers for heavy work in foundries are comparatively recent innovations, but from their simple construction and the enormous amount of work that they will accomplish, they are being rapidly adopted in this country and in Europe.

The method of erecting and using the Pneumatic Rammer is simplicity itself, and we have many different devices for suspending it and adapting it to any class of work.

By the use of this machine one man can readily do the work of from eight to twelve men using hand rammers. All he has to do is to stand in the pit and direct the blows of the rammer, moving the machine about over the work by means of the handles.

This rammer uses air at a pressure of about 80 pounds per square inch and strikes from 250 to 300 blows per minute. The air supply is absolutely under the control of the operator and he can thus regulate the force of the blow to the utmost nicety and start and stop the rammer at will.

The maximum force of the blow delivered by this machine is over three hundred and fifty pounds, while the average blow from a hand rammer is estimated at forty pounds. On the other hand the Pneumatic Rammer can be made to strike blows so light as to barely crack a watch

FOUNDRY RAMMER.

crystal. The entire regulation is accomplished by a simple movement of the controlling valve.

Progressive foundrymen will readily appreciate the advantages arising from the use of a machine of this kind. It is not only the great rapidity with which the work may be done that makes the Pneumatic Rammer a success, but the fact that the molds may be rammed much harder than is usually accomplished by hand labor.

It is possible to avoid entirely any "straining" in the mold with a consequent loss of metal and the frequent rejection of castings on account of "overweight." The latter point will be especially appreciated by steel founders.

If a sketch is sent to the Philadelphia Pneumatic Tool Co., Phila., showing the conditions to be met in any peculiar class of work, they will devise and furnish a means of suspension that will exactly meet your requirements. For ordinary plain work or pipe work standard devices meet most demands.

The smallest size Pneumatic Rammer requires no suspension, as it is light enough to be carried about by one man without difficulty.

They will be glad to furnish one of these machines to responsible foundrymen of ten days' trial. They are fully guaranteed against cost for repairs for one year from date of purchase.

Air Jet Pumps.

During a recent trip to the Missouri-Kansas zinc mining district I made quite a study of pumps, and the idea of using air in this mine pumping service occurred to me, and abides with me still. I started in as a matter of curiosity, for there is a prevalence of curious old walking beam pumps in that locality, but in studying the causes for the existence of this old curious pump in such numbers I came to study the requirements of the mines, which lead to an impression that air might enter as a factor of some magnitude in this industry. The mine depth will average about one hundred feet—varying from forty to two hundred—and quite a variety of pumps are in use. The old walking-beam pump is nothing but a straight pipe with a working barrel and piston near the bottom end, and it has peculiar advantages during the process of shaft sinking which accounts largely for its continued use. It is provided with a slip joint below the working barrel, which can be extended as the shaft deepens—to about twelve feet—and then there is only a top joint to screw on when the operation may be repeated. Also, it is very little in the way—only a pipe standing down in a corner of the shaft—and it is not so liable to get damaged during the firing of a blast, for it presents no working points to view, and a few pieces of plank stood up around it is all that is required in the way of protection. It seems that no modern pump has yet been devised that will meet such requirements and the result is that the old lift pump is put in for shaft sinking, and usually remains there for continuous service.

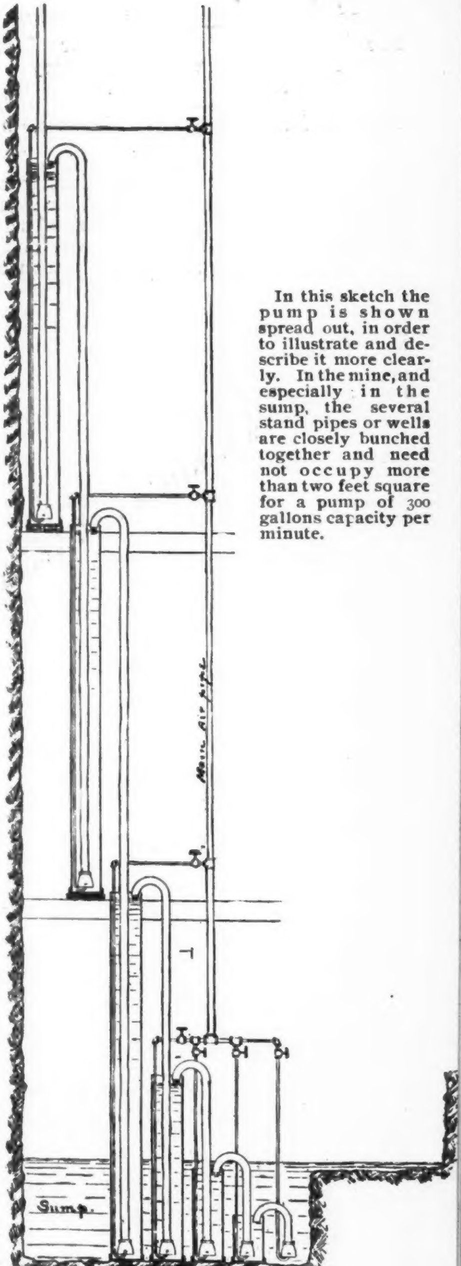
Some years ago there grew up among some southwestern sawmills a practice of using air for pumping under some peculiar conditions. There was plenty of water to be had—under ground—and the easiest, quickest and cheapest way to get it was to drive pipes, or bore wells. The depth of the water under ground was such that to suck it out with a surface pump was not satisfactory, and to put a pump down to the water called for the digging of a shaft. A builder of air compressors conceived the idea of running an air pipe down inside of the well or driven pipe and forcing the water out with compressed air—and it worked to the general satisfaction of the users.

Now, when I got to studying this mine pump question that using of compressed air to drive water up a pipe came to my mind and I began to make inquiries concerning its use—if it had been tried. It looked as if this ought to simplify the thing, even beyond that of the old walking-beam pump, but I was turned down in my ideas at first start by the theory that it requires something like sixty per cent. of the well to be filled with water before the air service could be made to do the work, or, in other words, if one wanted to pump water from a forty foot mine he would have to have a well pipe a hundred feet deep. Of course I knew a little something about this matter, and could understand that it would require a little water at the bottom of the well, but I did not like being stumped with the idea in such strong terms. I suggested that the pumping service could be divided into relays up along the pipe, and before leav-

ing the territory I found that there was something being done in that line. A man was driving water out of a mine with air and said he could handle it all right with a depth of ten feet in the bottom of his pipe. I think his well was something like a hundred feet deep, and the way he did it was something like this: He had an air jet at the very bottom of the pipe—piped down inside the main pipe—and about half way up he had another that would open when the water reached that point going up the pipe, and this one would then take up the burden of the work.

The idea that is still clinging to me is something after this plan; it seems to me that a series of air jets could be so arranged, with a line of small piping inside the main water pipe, that water could be lifted from any depth, and I offer the idea for study and experiment. A pump after this plan would be even less in the way, and more convenient in shaft sinking than the old lift pump that has clung on so long, but whether the idea is practical or not I am not able to say just now, and can only offer the matter herein as a subject for consideration. The valves along the line would seem to require some automatic appliance for their operation, etc., but it looks plausible. Taylor.

The contribution above appears to be in the line of compounding what is known of the Pohle Air Lift Pump which ordinarily lifts the water in one stage. The idea has been suggested before and we show a sketch outlining the method. This system has been adopted somewhere, but we do not know just where, and are not in a position to say anything as to its economy. It can readily be seen where it would have advantage over the old Cornish or walking-beam pump, as it would not require packing or replacing of parts. The Pohle Air Lift system having none of these and consisting simply of two properly proportioned pipes without valves or barrels instead of the Cornish or walking-beam type of pump. An ordinary sinking pump of the Cameron type is frequently used and operated with compressed air. Such a pump is subject to wear because of grit or acid in the water just as is the Cornish pump. The Air Lift possesses many advantages in pumping water where the conditions admit its use.



In this sketch the pump is shown spread out, in order to illustrate and describe it more clearly. In the mine, and especially in the sump, the several stand pipes or wells are closely bunched together and need not occupy more than two feet square for a pump of 300 gallons capacity per minute.

COMPOUND AIR LIFT PUMP.

Air Compression at High Altitudes.

The Reasons Which Cause Air Compressors to Give Less Efficiency at High Altitude.

Written for Mines and Minerals, by Robert Peele.

Because of the diminished density of the atmosphere at high altitudes, air compressors do not give the same results in mountainous regions as at sea level. Their effective capacity is reduced by reason of the smaller weight of air that is taken into the cylinder at each stroke. It is necessary, therefore, to make a deduction from the normal output of a compressor of given size, working with air at ordinary atmospheric pressure.

This matter is of special importance in connection with mining operations, because so many mines are at considerable elevations above sea level. The rated capacities of compressors, as given in the makers' catalogues, are for work at normal barometric pressure. This reduction in output is usually tabulated also in the catalogues, and must receive due consideration in order to avoid serious errors in ordering compressors. For example, the volume of compressed air delivered at 60 pounds pressure at an elevation of 10,000 feet is only 72.7 per cent. of the volume delivered at the same pressure by the same compressor a sea level. In other words, a compressor which, at sea level, will supply power for ten rock drills, will, at an elevation of 10,000 feet, furnish air for only seven drills. It should be observed that the heat of compression increases with the ratio of the final absolute pressure to initial absolute pressure. Therefore, as this ratio increases with the altitude, more heat will be generated by compression to a given pressure at high altitudes than at sea level, and there is a corresponding increased loss of work due to the subsequent cooling of the air.

Contrary to a common impression, the volume of compressed air delivered by a given compressor is not proportional to the barometric pressure, nor is the power consumed in producing a given volume of air at a given pressure the same at all altitudes. As a matter of fact, the volume of air furnished by compressors of equal capacity, working at different heights above sea level, diminishes at a somewhat slower rate than the barometric pressure, but the power consumed in producing a given volume of compressed air increases with the altitude. Take one compressor working at normal barometric pressure, assumed for convenience to be 15 pounds, and another working under an atmospheric pressure of 10 pounds, corresponding very nearly to an elevation of 10,000 feet. The first, if compressing to 6 atmospheres, will produce a gauge pressure of $(15 \times 6) - 15 = 75$ pounds. To produce the same gauge pressure the second compressor must work to an absolute pressure of $75 + 10 = 85$ pounds. This, divided by the atmospheric pressure of 10 pounds, gives 8.5 atmospheres required from the second compressor. The ratio between the two, $\frac{6}{8.5} = 0.706$, shows the relative volumes of compressed air produced under the assumed conditions. This is to be compared with the ratio between the corresponding barometric pressures, which is $\frac{10}{15} = 0.666$.

The indicated horsepower per cubic foot of piston displacement decreases as the altitude increases, but this decrease is not proportional to the altitude. To compensate for the increase of piston displacement per horsepower, when compressing to a given gauge pressure at high altitudes, some builders make the air cylinders of compressors for mountain work of larger diameter than those at sea level, for the same size of steam cylinder.

It is sometimes argued that compressors whose inlet valves are under some mechanical control are of special advantage for work at high altitudes. While there is a measure of truth in this the possible saving which may be effected is necessarily small. The matter presents itself as follows: If the valve resistance be reduced by introducing mechanical control, so that, under normal conditions at sea level, the inlet air begins to enter the cylinder a little earlier in the stroke, the volumetric capacity of the compressor is increased. The loss due to resistance of the valve springs, etc., which may be taken as a constant at 0.75 pounds for ordinary poppet valves, becomes proportionally of greater and greater consequence as the altitude increases, because its ratio to the atmospheric pressure is increased. The percentage of saving obtained by eliminating the spring resistance, though small at sea level, therefore

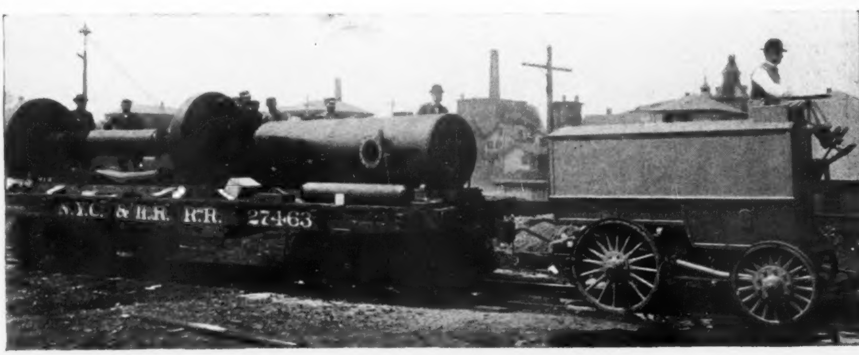
bears an increasing ratio to the atmospheric pressure as the altitude increases. In other words, the inlet valve which presents the smallest resistance at normal atmospheric pressure will be the most economical valve as the atmospheric pressure decreases.

According to the statement made above, the greater the altitude above sea level the smaller will be the ratio between the final pressure at delivery and the atmospheric pressure, that is, the ratio of compression. It is evident, therefore, that the percentage loss due to piston clearance increases with the altitude. It may be questioned whether it is worth while to adopt stage compression for the ordinary pressures used in mining and tunneling, but the case is materially altered at high altitudes. For example, if it be desired to produce a gauge pressure of 75 pounds at an altitude of 5,000 feet, 7.15 compressions are necessary. At sea level this ratio of compression would produce a gauge pressure of 105.1 pounds. So far as the losses due to piston clearance are concerned, therefore, it is as reasonable to employ stage compression for a gauge pressure of 75 pounds at 5,000 feet elevation as for 105.1 pounds at sea level. In a compound compressor, too, it must be remembered that there is but one clearance space; that in the low pressure, or intake, cylinder. The value of the intercooler also increases with the altitude. —Mines and Minerals.

Traction and Auto-Mobile

Hoadley-Knight Auto-Truck.

Following are illustrations and descriptions of compressed air propelled vehicles showing the development in the line of the auto-truck. The New York Auto-Truck Co. has been carrying on a line of experiments to demonstrate the feasibility of compressed air vehicles for street haulage. Notwithstanding the fact that without pipes in the streets for the transmission of compressed air there can be no compressed air automobile, experiments along these lines bring us nearer to the desired "public supply."



HOADLEY-KNIGHT TRACTOR PULLING RAILROAD CARS.

The first carriage of this type was built in 1895 and 1896, to establish the general principles, the mileage, regulation and control by this power. The power was applied by a Hoadley-Knight motor. It was found that on one charge it would run 14 miles and ascend a grade of 20 per cent. at eight miles an hour. Air was reheated by a small coal fire.

The second vehicle was the factory truck for handling heavy weights around the factory yards at Worcester, Mass.; it was capable of carrying ten tons. This

vehicle had no provisions for reheating, as it was not required to run long distances, and it could be recharged at any moment.

With this development to demonstrate the power and feasibility of compressed air a tractor was built, which was a sort of compressed air locomotive. The power was controlled by the feet and the steering was done by the hand. Controlling treadles extended out from the standard in front of the driver's seat, convenient as a footrest. By pushing one foot down the vehicle was caused to go forward, and by pushing the other foot down it was caused to go backward, while putting both feet down in a medium position brought the vehicle to a standstill. This tractor is said to have developed 100 H.P. and to have hauled 40 tons on railroad cars. Hot water under 600 pounds steam pressure was used for reheating.

The tractor may be seen hauling railroad cars and also pulling coal wagons on the streets of Worcester, Mass. Other tractors were built on similar lines, and were used in Providence, R. I., at the works of the International Power Co., for factory work. In connection with a low-gear truck, the forward wheels of the low gear being dispensed with, and its forward end being hung by a link under the rear axle of the tractor, thus making a "lorry" of the tractor. This was followed by the auto-truck, which was adapted to carry a load on its back, and represents the most powerful automobile which has yet been produced. It is capable of carrying a load of ten tons up a grade of 10 per cent. The view shown in Figure 4 was taken in Providence, R. I., doing factory work, hauling castings of the largest size. It was afterwards taken to New York and used there (See Figure

AUTO-TRUCK IN FACTORY WORK.

5) for hauling lumber. The weight of the load shown is 18,000 pounds. This truck is the prototype of other trucks now being built by the International Power Co., and they differ in points, weights and material. The weight of the new truck is much less and the material of a character designed for permanency.

Pneumatic Tools

Special Edition of Catalogue No. 9 has been issued by the Chicago Pneumatic Tool Co. and comprises interesting illustrations of that company's varied appliances. Some of the newer applications shown are the oil rivet forge, piston air drill at work in blast furnace, and driving boring bar in coal mining, also operating the Tynan Patent Side Light Cutter and boring an undercut in a bank of salt. The utility of the air drill is quite past enumeration, since it suggests new uses under new conditions. The Catalogue is the organization under one cover of all the devices made by the C. P. T. Co. The letters from the largest ship-building concerns in the United States are unusual in the matter of giving detailed instead of general facts. The book is desirable and can be procured by request.

COMMUNICATIONS.

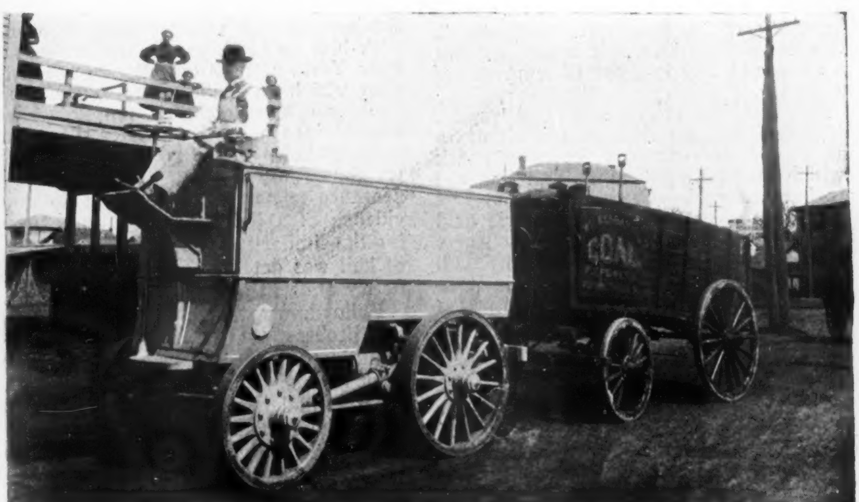
Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz., all communications should be written on one side of the paper only; they should be short and to the point.

What is the Cause of Thunder?

To the Editor of Electrical Review:

What is the cause of thunder, meaning the cause of the noise? We do not know. The thunder, we know, is a result of the phenomenon we call "lightning," but just what it is has not been as yet adequately determined. The electric discharge produces a variety of effects, physiological, luminous, calorific, magnetic, mechanical



TRACTOR HAULING COAL WAGON.

and chemical, whose characteristics are more or less well recognized. It is fair to presume that we must hunt for the cause of the noise in the calorific, mechanical or chemical attributes.

Most of the authorities in definition say thunder is the noise immediately following a flash of lightning, and is due to the disturbances of the air caused along its path by the discharge, and they let it go at that. It may be that the real explanation will be found partly in each of the calorific, mechanical and chemical actions. A mere disturbance of the air is hardly an adequate reason. We have too little evidence to go upon. The heating effects, so-called, may have some bearing. We know the spark will inflame ether, alcohol and some of the hydrocarbon gases: yet it does not ignite gunpowder, except by the help of a wet string which becomes heated. A Leyden jar charged and discharged several imes in rapid succession becomes heated. All solid conductors become heated by it. But does air? Mechanical effects are numerous and usually disastrous to any solid body not a good conductor. We are shown by Kinnersley's thermometer that some effect is produced on a body of water, but it is asserted not to be due to any increase of temperature in the air.

The chemical effects are most varied. Priestly found a reduction of volume in moist air by passage of the spark (which may be significant), and that the air became acid. Cavendish found this was due to the formation of nitric acid by the chemical action of the discharge. Compound gases are readily decomposed, but air is not a compound gas; it is merely a mixture of oxygen and nitrogen and neither of its constituents is combustible. One assists combustion of other bodies, while the other is inert in that sense.

But we may get some light on the subject yet from the indefatigable army of electrical investigators. Possibly the researches in the liquefaction of gases may help out. In a recent paper on the subject, it is stated that ozone liquefies at atmospheric pressure at a temperature of 135.4 degrees Fahrenheit, and that it is easily exploded. Now, it is well known that the electric discharge produces this so-called allotropic oxygen in great abundance. According to Priestly, the electric discharge effects a reduction of volume in moist air, which would indicate ordinarily a fall of temperature. Moist air is the usual atmospheric condition during lightning flashes. Possibly the stream of innumerable sparks in a stroke of lightning produce a cumulative or intensive effect, first lowering the temperature, then forming ozone, then causing its liquefaction and finally its explosion, or perhaps detonation, which expresses more accurately the terrifying crash following or accompanying a lightning stroke near at hand. This is mere speculation and I give it for what it is worth.

M.

Hoboken, N. J., January 27, 1900.

The above correspondence is taken from the Electrical Review of January 31st last, and it opens a field for discussion, the result of which may not only account for the phenomena of thunder and lightning, but also of hail. The recent developments in electricity has not given us any evidence that it is the direct cause of any of these phenomena.

The developments in Liquid Air, however, would lead the writer to ascribe to that process the cause of each of them. During the past summer the writer took with him to his home in the suburbs of New York, a small quantity of liquid air with which to make some experiments. Among others, some of the liquid was poured into a bowl of water. Immediately globules of ice were formed. The ice thus formed is very different in appearance to natural ice, and by the coincidence of a hail storm the same evening the similarity of the globules and balls of hail was detected. The two are practically alike in shape and color.

Following up this clue to a conclusion, the process of the production of hail, lightning and thunder can be understood or at least an idea that may perhaps give a better understanding of these phenomena. The mechanical process of liquefaction of air is that air is compressed and cooled down until it liquefies. When liquefied it combines the elements of cooling, lightning and thunder.

It is well known that air may be compressed to almost any pressure by falling water, but it must be enclosed. Now we must assume that a cloud hanging heavy in the atmosphere begins to descend when it precipitates what we call rain. Naturally at the beginning of the descent it

creates a pocket or vacuum between itself and the clouds hanging above it. The draft produced induced the next cloud above to also descend, and it would do so with much more rapidity than the first one. As the first cloud approaches the earth it meets with a certain resistance, consequently with the first cloud's retarded progress and the second cloud travelling through the pocket the air between would be compressed to the whole extent of the pressure which would be exerted in the chase of the one by the other, whatever that might be. Another condition presents itself here, and that is that air compressed by falling water is practically dry, and this dryness is more or less essential to liquefaction. It is easy to perceive that air under these conditions would soon liquefy. When liquefied it would have the effect upon the atmosphere that would produce hail, lightning and thunder. Because hail is different from snow it is necessary that it should go through a different process of crystalization. Drops of water falling must come in contact with something besides cold: cold would have the same invariable effect on drops of water, and if it was produced by intense cold why is not all of the rain frozen at the same time? Cold does not disintegrate: It cannot.

A fierce gale of wind always precedes a fall of hail, and this is another proof of the pocket spoken of. In the matter of thunder, it may be explained that liquefied air cannot be confined and when it has travelled in the pocket which it went into for a distance it certainly comes in contact with warmer strata of atmosphere and the instant it does there is an explosion that would not only produce a loud noise, but would also produce light from its own vehemence.

There are some existing conditions which are not mentioned above. For instance: Hail does not always fall when there is thunder, at least, we do not always see it. It may fall in some other locality, because hail sometimes falls on one side of a street and not on the other. There are summer heat flashes of lightning that are quite unexplainable by these arguments, but where violent concussion and accompanying light take place the coincidences are so evident that the idea of liquid air being the source is certainly more than a theory. J. D. F.

PATENTS GRANTED JAN., 1900.

Specially prepared for COMPRESSED AIR.

640,184. AIR-PROPELLER. Andrew Duffner, Jr., Toledo, Ohio. Filed April 15, 1899.

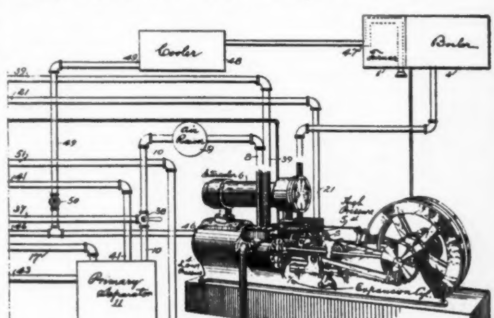
An air-propeller, comprising an arbor, having mounted thereon a spider, and two or more concentric series of buckets secured to the spider, the buckets of the successive series increasing in capacity and diminishing in number from the periphery inward proportionally to the radial velocity of each series.

640,318. APPARATUS FOR DRYING AIR. Alfred T. Perkins, Chicago, Ill. Filed October 13, 1896. Renewed November 21, 1899.

A battery for cooling air and for precipitating the moisture contained therein, consisting of a cylindrical chamber containing ice or other cooling agent, a plurality of closed air-receptacles on the outside of said chamber, a supply-pipe for air entering one of said receptacles, a screen in said pipe for breaking up the air into fine particles and admitting it in the form of a spray into said receptacle, pipes connecting the adjacent pairs of said receptacles arranged alternately at the upper and lower ends thereof, screens in said pipes, and valved drip-pipes in the lower ends of said receptacles for drawing off the water of condensation.

640,320. SYSTEM FOR STERILIZING, DRYING AND COOLING AIR. Alfred T. Perkins, Chicago, Ill., and Frederick C. Weber, New York, N. Y. Filed December 5, 1896. Renewed November 21, 1899.

The combination with apparatus for sterilizing air, a compression-cylinder and an expansion-cylinder for the air, and a storage or preserving compartment, of a primary separator, a pipe leading from said



compression-cylinder to a primary separator for conveying the air under pressure at a high temperature thereto, a pipe leading from said expansion-cylinder to the primary separator, a reheater communicating with said primary separator, a supplementary separator communicating with said reheater, a cooler communicating with said supplementary separator, a pipe connecting said cooler with the pipe leading from said compression-cylinder to said primary separator, a three-way cock at the meeting-point of said pipes, a pipe also leading from said cooler to said expansion-cylinder, a pipe leading from said primary separator to said supplementary separator for the air from said expansion-cylinder, a pipe leading from said supplementary separator to said storage-chamber, a pipe leading from said storage-chamber to said compression-cylinder communicating with the pipe leading from said sterilizing apparatus, a pipe leading from said chamber to the pipe leading from said expansion-cylinder, and a three-way cock therein.

640,386. PNEUMATIC-TRANSFER-TUBE SYSTEM. Sterns F. Jones, New York, N. Y. Filed May 17, 1899.

The combination of a transfer-tube connecting two stations, a door in the tube at one station, and air-pump and a motor for alternately drawing and driving air through said tube, a main electric circuit to control said motor, switches at each station to control said circuit, a magnet to control said door, a local circuit for said magnet, a circuit-closer in said circuit operated by the switch at one station and a circuit-breaker in said local circuit operated by the passing carrier at the other station.

640,890. AIR AND GAS ENGINE. John W. Eisenhuth, New York, N. Y., assignor to Mamie G. Read, same place.

A compound gas and air engine, in combination with high-pressure gas-cylinders and high-pressure air-cylinders, of a low-pressure cylinder adapted to receive and be operated by the exhaust from both the high-pressure gas-cylinders and the high-pressure air-cylinders, and a vacuum-chamber for drawing the exhaust from the said low-pressure cylinder.

640,946. AIR - EJECTING APPARATUS FOR VESSELS. Gustave Quanonne, Houdeng-Goegnies, Belgium. Filed February 17, 1899. Serial No. 705,842. (No model.)

The combination of a vessel and with its body of compressors operating by reduction of volume, a single transmission-shaft actuating the compressors, cranks keyed at different angles and connecting the said compressors to the said single transmitting-shaft, a regulating-reservoir for the continuity of the air-current, branched pipes into which the said compressors and the said reservoir force air, ball-valves interposed in the said pipes and acting through the effect of the vis viva of the air-current to moderate the latter, distributers connected with the said pipes and distributing the compressed air over different sections of the body independent of one another and means for concealing the said distributers in the sides of the vessel.

640,949. AIR - COMPRESSING ENGINE. Edward A. Rix, San Francisco, Cal. Filed June 30, 1898.

Claim.—In an air-compressor, having a cylinder, piston, and inlet and outlet valves, the combination with the inlet-valves of mechanism to actuate said valves, and means exposed to the pressure in the outlet-pipe controlling the operation of said mechanism, whereby the inlet-valves are closed at some point of the compression-stroke varying with the dependent on the pressure in said outlet-pipe or its connection, substantially as specified.

641,409. AIR PUMP. Charles E. Scribner, Chicago, Ill, assignor to the Western Electric Company, same place.

The combination with a mercury vacuum-pump, of a vessel of mercury connected with the exhausting-chamber thereof, an air-passage leading into said chamber, and a valve controlled by a float in the said vessel of mercury and constructed when seated to restrict the flow of air through said passage and thereby to reduce the rate of flow of the mercury into the chamber, whereby the flow of mercury into the chamber is retarded after a predetermined point, substantially as described.

641,384. PNEUMATIC-DESPATCH TUBE. Charles A. Gray, Kansas City, Kans., assignor of one-half to John Logan Jones and Laurence Monroe Jones, same place. Filed April 7, 1899.

A pneumatic-despatch apparatus in combination with a pneumatic-despatch tube having an opening in one side thereof of a valve, lugs upon the upper end of said valve a pin extending through the sides of said despatch-tube and said lugs, a spiral spring upon said pin having one end connected therewith and the other end bearing upon the under side of said valve, a ratchet-wheel on said pin on the outside of said tube and a pawl pivotally connected with said tube and engaging with the said ratchet-wheel.

641,505. AIR-LOCK FOR CAISSONS, &c. Richard S. Gillespie, New York, N. Y.

An air-lock for caissons, comprising a casing having a rounding end portion with an opening therein for the passage of a bucket, and gates to close said opening, the gates being pivoted at the ends and shaped and hung so as to follow the walls of the casing and form when closed a practical continuation of said walls across the opening, said gates being geared together so as to open and close in unison, substantially as described.

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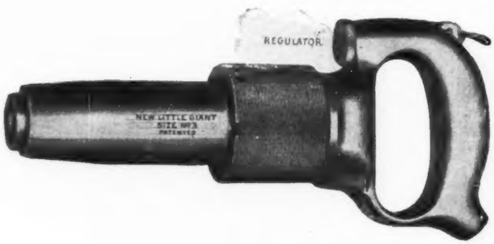

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